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PROTEIN AND AMINO ACIDS IN DIETS

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Nutrition-conscious Americans today are hearing a lot about protein—protein for the young and the no-longer young—protein for weight reducers, for pregnant and nursing mothers—protein in sickness, protein in health. Why this current emphasis on protein, a dietary component long known to be essential in nutrition? One reason is that our rapidly growing knowledge of amino acids that go to make up proteins gives a basis for a new look at protein nutrition. Some of the current facts and thinking about our needs for and supplies of protein and amino acids are summarized here.

WHY WE NEED PROTEIN

Protein is an essential substance in every living cell in the body. It makes up a large part of the solids in muscle cells, but it has important functions in all body tissues—blood, skin, hair, bone. Protein contains nitrogen which is needed for the upkeep of cells, for glandular secretions, and for the building of new body substance. Everyone has a maintenance requirement for protein. Children, because of the demands for growth, need more protein than adults in proportion to body size.

HOW MUCH PROTEIN DO WE NEED?

Protein allowances for normal adults have, for some years, been set at 1 gram per kilogram of body weight. These allowances were based on studies of nitrogen balance, in which nitrogen intake and output on various diets were compared. Nitrogen equilibrium, however, where output equals intake, can be obtained at any level of protein intake above a certain minimum level, dependent on basal metabolism. This is explained by the concept that tissue proteins are in a dynamic state, that they are constantly breaking down and resynthesizing; that some are depleted or repleted as the amount of protein in the diet is varied. Although nitrogen equilibrium may be established at relatively low intakes, this does not mean that protein stores are adequate in all body tissues. Hence, the nitrogen balance method of determining protein requirements is not entirely satisfactory. It is useful in determining the minimum intake but does not answer the question as to what is optimal intake.

A better understanding of protein requirement is made possible through present knowledge of amino acids. There are some 22 amino acids used for the growth and maintenance of body tissue and for certain other functions. Some of these amino acids can be synthesized by the body; they are called "dispensable" or "nonessential." Others that cannot be synthesized in adequate amounts to meet body needs are called "indispensable" or "essential." For adults 8 of these must be provided by the diet—tryptophan, threonine, isoleucine, leucine, lysine, methionine, phenylalanine, and valine. Children appear to need another one, histidine.

Quantitative amino acid requirements of young adults have been studied extensively. Some data are available also on requirements of infants. These are the principal groups that have been studied thus far. Many problems have been encountered in designing the experimental procedures and in interpreting results. It is very important, for example, that the experimental diet be well balanced. The content of minerals and vitamins and especially the caloric value of the diet may affect nitrogen retention. It has been found that experimental diets containing individual amino acids rather than food proteins, require calories in excess of normal intakes to maintain nitrogen balance. Other factors found to influence requirements for essential amino acids are the total intake of nitrogen, including the nonessential amino acids, and the proportions of essential amino acids in the

diet. Because of all these interrelationships much more research is needed to establish quantitative requirements for individuals of different age and sex, consuming ordinary mixed diets.

In the groups studied thus far, the proportions of the required amino acids for young men, women, and infants appear to be similar, although the absolute amounts differ.

HOW MUCH PROTEIN DO WE GET?

Our national food supplies, in the 50 years in which records have been kept, have provided generous amounts of protein that average between 90 and 100 g. per person per day (*1*). During this period, the proportion of protein from animal sources has gradually increased from about one-half in 1909-13 to two-thirds in 1957. This change reflects the fact that we are eating increasingly more dairy products, eggs, and to some extent meat, and at the same time less grain products.

From household studies we learn more about food consumption of different groups in the population, and some of the factors affecting family diets. The nationwide study made in 1955 showed that household food supplies provided about 103 g. of protein per person (*2*). Wide variation was found among different households at all income levels and in the several regions. For example, 4 percent of households in a low income group, $2,000 or less for the year, consumed foods that furnished less than 50 g. of protein per nutrition unit (equivalent adult male unit) per day. On the other hand, 19 percent in this income class had 150 g. or more. In the whole group only 8 percent of the family diets failed to provide the recommended protein allowances of the National Academy of Sciences-National Research Council (NAS-NRC).

Diets of individuals also vary greatly in protein content, reflecting different food choices and to some extent differences in total food consumption.

Relatively high protein intakes, perhaps twice the recommended allowance, are not uncommon. On the other hand, although protein is less apt to be low in diets than other nutrients, many persons do not have the amounts specified in the NAS-NRC Recommended Dietary Allowances.

Diets of younger children usually are better than those of older children. Because of larger food intake, older boys are more likely to have recommended amounts of protein than girls. Women's diets are often low in protein compared with the NAS-NRC Recommended Dietary Allowances.

A study of 1-day meals of about 1,000 homemakers in 4 cities in 1948 showed that about one-half had less than the recommended amount (60 g.) of protein in their meals on that day (*3*). One-fourth had more than 80 g.

Older people often find it hard to eat enough food to provide for their nutritional needs. Without special wisdom in choosing food their diet may be short in protein as well as other nutrients. In one study in Iowa (*4*), the proportion of women with less than 50 g. of protein in their diets was twice as high for those 70 years and over as for those 30 to 39 years old. A cooperative study in the western region (*5*) showed that the mean protein intake of females decreased gradually with advancing age. At ages 13 to 17 years, protein intake averaged 70 g.; at 25 to 49 years, 67 g.; 65 to 69 years, 61 g.; and 75 to 79 years, 53 g.

It seems clear from these and other studies that family members do not share equitably in the food supplies of the household and the nation, which provide generous amounts of protein.

AMINO ACIDS IN FOODS

Food proteins differ in the amounts and proportions of amino acids they contain and therefore differ in the efficiency with which they can be used by the body. The most efficient proteins are those in which the proportion or pattern of essential amino acids is similar to the pattern required by the body. Since animal tissues in different species tend to contain amino acids in somewhat the same proportions, it is not surprising that meat, fish, eggs, and milk are the most efficient food proteins. These have sometimes been called "complete" proteins in contrast to those of vegetable origin, which are less efficient for tissue building and which have been called "incomplete."

For many years the usual way of determining the efficiency of a protein was through feeding experiments with growing animals. Now, however, the nutritive value can be estimated from recently developed tables, which give the amounts of the essential amino acids in common foods (*6*). From these data the proportions or patterns of amino acids in various foods can be determined and compared with a pattern of human requirements or with that in a food of high biological value. Egg protein is often used as a standard of comparison.

This kind of information is useful in estimating the probable efficiency of the protein in a food. It shows which amino acids are likely to be limiting and the way in which one food protein can supplement another. This is of great practical importance because most people eat more than one food at a meal. It is the protein quality of the food eaten at one time, rather than the individual foods, that counts. In many areas of the world where protein foods of good quality are in short supply, the possibilities of improving diets through com-

bining foods that supplement each other in amino acid content are very promising.

AMINO ACIDS IN DIETS

With composition values available it is now possible to calculate the amino acid content of diets and food supplies. These values can be interpreted in the light of some standard of requirement or recommended intake. For example, minimal requirements and safe allowances of essential amino acids for men have been proposed by Rose and his associates (7). Similarly, average minimal requirements for women have been studied by a number of workers at Experiment Stations in cooperation with USDA. At present, however, no agreed-upon amino acid allowances such as the Recommended Dietary Allowances of the NAS-NRC for other nutrients have been developed. As indicated above, many gaps must be filled before this will be feasible.

To give a rough idea of the supply of amino acids in average diets the content per day of the U. S. per capita food supply in 1953 and, for comparison, Rose's minimal requirements and "safe allowances" for men are given below:

Essential amino acid:	U. S. per capita food supply 1953[1] (*g. per day*)	Minimal requirement of young men[2] (*g. per day*)	Safe allowance[2] (*g. per day*)
Tryptophan	1.2	0.25	0.50
Threonine	3.9	.50	1.00
Isoleucine	5.2	.70	1.40
Leucine	8.0	1.10	2.20
Lysine	6.1	.80	1.60
Methionine	2.0	[3] 1.10	[3] 2.20
Total sulfur-containing	3.4	1.10	2.20
Phenylalanine	4.6	1.10	2.20
Valine	5.5	.80	1.60

[1] Computed by Household Economics Research Division, ARS USDA, based on estimates of per capita consumption supplied by AMS, USDA.
[2] Rose. See reference No. 7.
[3] Methionine is the essential sulfurcontaining amino acid but the nonessential cystine can spare methionine up to 80 per cent.

It is not surprising to find liberal amounts of amino acids in a food supply providing 96 g. of protein per person, two-thirds of which is from animal sources.

Diets of individuals in the population will, of course, deviate greatly from the average. To illustrate what may be found in diets called "poor" by usual standards, calculations were made of the amino acids in 1-day's food intake of 10 women who had on that day an intake of 40 g. of protein. This is about two-thirds of the recommended allowance. The range in amounts found and, for comparison, tentative minimal requirement figures for women derived from USDA's cooperative studies are shown, as follows:

Essential amino acid:	1-day diets of 10 women (range)[1] (*g. per day*)	Average minimal daily requirement women[2] (*g. per day*)
Tryptophan	0.3-0.6	0.16
Threonine	1.5-1.9	.30
Isoleucine	1.8-2.4	.45
Leucine	3.0-3.7	.62
Lysine	2.0-3.1	.50
Methionine	.6-1.0	.35
Total sulfur-containing	1.1-1.6	.55
Phenylalanine	1.7-2.2	.22
Valine	2.2-2.6	.65

[1] Unpublished data from 1948 Study of Family Food Consumption, Household Economics Research Division, ARS, USDA.
[2] From report of Committee on Amino Acids, in preparation, to be issued by Food and Nutrition Board, NAS-NRC.

The diets of these women appear to cover average minimum requirements with a liberal margin of safety. The margin is least for tryptophan and the sulfur-containing amino acids. No information was obtained, however, on the women's state of protein nutrition. The diets were poor or borderline in many nutrients and some were low in calories. Since requirements for amino acids are affected by the calorie level, the total nitrogen intake, the amounts and proportions of essential amino acids, and by levels of other nutrients in the diet, it is difficult with our present state of knowledge to evaluate the adequacy of amino acid intakes, particularly in borderline diets.

AMINO ACID SUPPLEMENTATION

It has been long known that not all foods are capable of supporting good growth in young animals. Early studies showed, for example, that young rats grew poorly when wheat was the only source of protein in the diet. The addition of milk restored growth to a normal rate. In time it was established that lysine was the first limiting amino acid in wheat protein.

A logical next step might seem to be the addition to foods of individual amino acids needed to improve the nutritive value of the protein. This is now common practice in animal feeding. The increasing availability of synthetic amino acids makes this a possibility also for foods for humans. Lysine now on the market is, in fact, being added to a few cereal products at the present time.

The question arises whether the fortification of all wheat flour with lysine would be a desirable procedure. This calls to mind the "Statement of General Policy in Regard to the Addition of Specific Nutrients to Foods" issued by the Food and Nutrition Board of the NAS-NRC in 1953. The statement in part follows:

"With carefully defined limitations, the principle of the addition of specific nutrients to certain staple foods is endorsed for the purpose of maintaining good nutri-

tion as well as for correcting deficiencies in the diets of the general population or of significant segments of the population. The requirements for endorsement of the addition of a particular nutrient to a particular food include (a) clear indications of probable advantage from increased intake of the nutrient, (b) assurance that the food item concerned would be an effective vehicle of distribution for the nutrient to be added, and (c) evidence that such addition would not be prejudicial to the achievement of a diet good in other respects."

At present, the need for amino acid supplementation of flour or other grain products used in ordinary mixed diets has not been clearly demonstrated. With protein of good quality widely available and generally included in diets, there is little likelihood of a shortage, particularly of lysine. As shown above, the women's diets, providing 40 g. of protein, contained at least 4 times the minimum requirement of lysine tentatively proposed for women. Undoubtedly some groups in the population would benefit from an improvement in the protein quality of bread or other cereal products. Perhaps they are tea-and-toast eaters, or perhaps the good-quality protein in their diets is not well distributed among their meals.

Fortunately many of our favorite food combinations are good examples of amino acid supplementation. These include such familiar foods as cereal and milk; macaroni and cheese; beans and frankfurters; egg, cheese, meat, or peanut butter sandwiches. In each example the vegetable protein quality is improved by the addition of animal protein, or another kind of vegetable protein as in the peanut butter sandwich. This kind of supplementation could be developed much more fully in nutrition education materials.

A large share of the recommended protein allowances can be met by following "A Daily Food Guide," U. S. Dept. Agr. Leaflet 424, which suggests for adults 2 servings of meat, fish, or eggs; 2 servings of milk or other dairy products; 4 or more servings of vegetables or fruit; and at least 4 servings of bread or cereal.

SUMMARY

Protein supplies in the U. S. A. are generous. Nevertheless studies repeatedly show that a considerable proportion of persons have less protein in their diets than the amounts specified in the NAS-NRC's recommended allowances. These allowances are probably well above average minimal needs. Sample calculations of the amino acid content of the so-called poor diets show that tentative minimum requirements for essential amino acids were well covered.

Although supplementation with synthetic amino acids offers a potential for enhancing the nutritive value of individual foods, there is no clear-cut evidence of advantage to be gained from such a program in the United States. It is the quantities and proportions of amino acids in the meal that is important rather than in individual foods.

In planning food supplies to meet protein requirements, both the quality and quantity of dietary protein must be considered.

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INFORMATION PLEASE

Many of you have requested an issue of NCN dealing with the nutrition problems of senior citizens. If you have faced the problem of promoting improved eating habits among this age group and are willing to share your experience with others, please send your stories in now. Our readers have found the most interesting stories to be those which include details of background, procedures, and outcomes. We shall also appreciate leads to other people or agencies that have material on this subject.

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